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The Boxwood Leaf Miner

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Bureau of Plant Industry

75-Year-Old Boxwood in Yard of Dr. Martha L. Bailey, Dillsburg, Pa.

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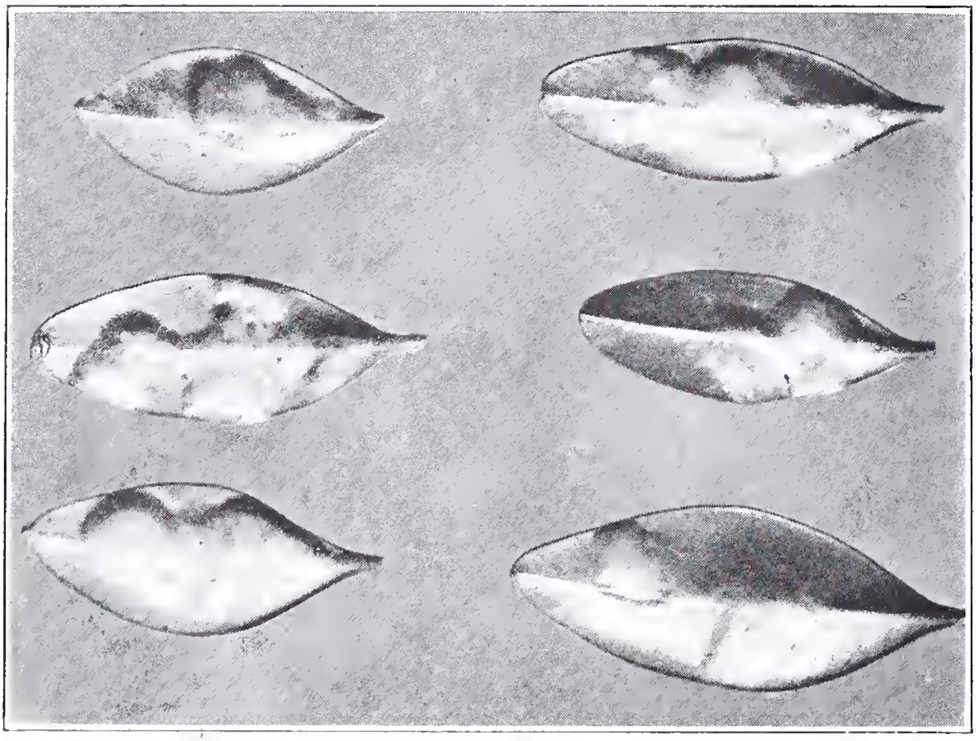

Fig. 1. Boxwood Leaves Showing Characteristic Blister-Like Mines on Lower Surface.

The Boxwood Leaf Miner

(*Monarthropalpus buxi* Labou)

By Floyd F. Smith and Herbert J. Fisher[1]

Bureau of Plant Industry

The boxwood leaf miner is undoubtedly the most serious insect enemy of boxwood in Pennsylvania and probably wherever it is grown in the United States. The boxwood plant is gradually weakened by the reduction in normal leaf areas due to the mining of the larvae within the leaves. The effect of a single larva in a leaf is not great but, once established, the insects rapidly increase each year until nearly every leaf is more or less completely eaten out inside. The foliage, which in health is of rich dark green color, when miner-infested becomes yellowish green; new growth is short and many twigs die out which results in a straggly appearing plant of little ornamental value. (See Fig. 1). The weakened plant may then be more subject to attack by certain diseases, especially *Macrophoma* sp., or may be subject to winter killing.

Eleven varieties of *Buxus sempervirens* have been observed to be heavily infested. The dwarf English boxwood, var. *suffruticosa,* is very rarely infested and seems to be quite generally immune to leaf miner attack. The varieties *pendula* and *argenteo-variegata* were the only ones found to be entirely immune. The glossy leafed *Buxus microphylla* var. *Japonica* is severely attacked.

LIFE HISTORY

The boxwood leaf miners have one generation each year. The partly grown larvae pass the winter within the leaves. On warm days they feed and grow, and in March and April they develop very rapidly. About mid-April growth is completed, the transparent "window" is formed in the lower leaf surface, and the insects transform to the pupal stage. About three weeks later the pupal heads become dark brown. Within a day or two, about the time of first appearance of blooms on weigelia, and mock orange and the showing white of the blooms of snowballs *(Viburnum opuli-sterilus)*[2], the pupae break the "windows," project their bodies outside the leaf and split down the back. The adult orange colored flies then quickly come out of the pupal skins and are soon dry and flying about. The largest number of adults emerge between midnight and mid-forenoon. The adults mate and begin laying eggs within two or three hours after emergence, and die either the same or the next day. During the adult life no food is taken. The eggs are placed deeply within the tissues of the young leaves and the cavities formed by insertion immediately close and heal over. The eggs hatch in about nineteen days and the larvae feed little and grow slowly until fall when they begin to increase considerably in size.

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[1] The authors are grateful for the cooperation of Mr. W. W. Harper, President of the Andorra Nurseries, Inc., Chestnut Hill, Pennsylvania, who kindly placed at their disposal for experimental work the desired plants and also supplied considerable equipment and labor whenever needed.

[2] The exact date of first emergence varies from year to year but, based upon four years' observations, the blooming of the above mentioned plants coincides very closely with the appearance of the first adults.

CONTROL

Because the insects are entirely within and protected by the leaf during their entire lives, except the few hours spent by the non-feeding adults, the problem of control seems to be quite baffling. No chemical-containing spray or dip has yet been found which will kill the insects within the leaves without severely injuring the host plant. To control the insects by sprays they must be attacked in the adult stage. Cory (1) and Hamilton (5) developed the molasses-nicotine spray (molasses 1 pint, nicotine sulfate 1 teaspoonful to 7 pints of water) which gave excellent control by killing and entangling the adults. The senior writer obtained almost equally good control by a daily thorough application of a dust containing 5% by weight of 40% nicotine sulfate in a carrier of kaolin or hydrated lime, applied during the emergence period. To be effective, dusts and sprays **must** be carefully applied at the beginning of the adult emergence period and repeated at definite intervals. Additional applications must also be promptly made after rains since adults come out in large numbers following warm showers. If one has an extensive planting of boxwood, it is usually impossible to properly protect all of it because of lack of equipment or labor. In searching for additional controls, the methods—(a) fumigation with cyanide and (b) hot water immersion, were developed.

FUMIGATION WITH CYANIDE

Felt (3) and Hamilton (4) conducted limited tests in the laboratory by fumigating larval infested branches with cyanide. These tests showed interesting possibilities of the use of this material and led to the planning of the cooperative work in this problem between the Pennsylvania Bureau of Plant Industry and the United States Bureau of Entomology.*

Fumigation experiments were conducted for three years on box-bushes growing in the field to discover the conditions under which the larvae could be killed within the leaves with no serious injury to the plant. These experiments demonstrated that from 98 to 100% of the larvae could be killed without injuring the boxbush but certain conditions must be observed or serious damage may result. Because of the dangerous nature of the sodium cyanide and because of the necessary observance of the conditions required for performing a successful fumigation, the work should be entrusted only to a responsible person.

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* The experimental work on which these recommendations are based was performed in the years 1925 to 1928 by the writers in cooperation with William Middleton of the Bureau of Entomology, United States Department of Agriculture. It is expected that the data secured in the course of these experiments will be published in complete detail later.

EQUIPMENT

The equipment employed consisted of the following:

The frame. For convenience in calculating dosages on the basis of cubic feet, a frame 4′ x 5′ x 5′ was constructed of light wood. Uprights five feet long of 2″ x 3″ material were connected on opposite sides by 6″ x ½″ boards five feet long and at the ends by 6″ x ½″ boards four feet long. The corners of the frames were rounded to prevent tearing of the cover.

The covering. Canvas sheets 16′ x 18′ composed of twelve ounce duck and painted on both sides with linseed oil and allowed to dry a few days were found satisfactory for this work. This size canvas covers the frame described above and leaves a margin of about one foot around the sides and ends for sealing.

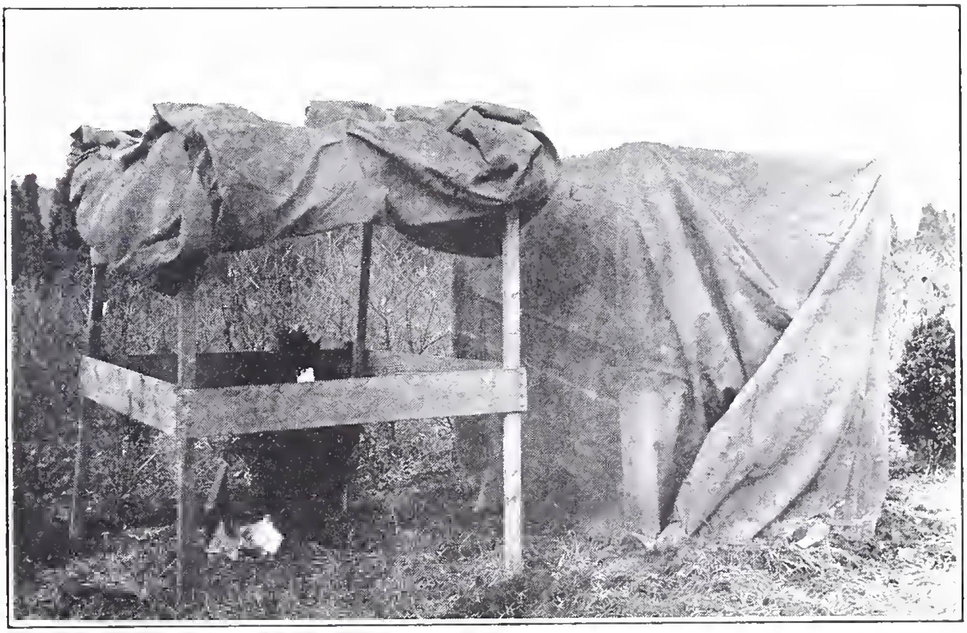

Fig. 2. Tents used for Cyanide Fumigation, one closed and sealed during Fumigation and the other opened and ready to be moved to another plant.

It was found that a tent of untreated canvas of the same grade required a considerably larger dosage of cyanide fumigant than the linseed oil-treated tent because of greater gas leakage. A commercially treated canvas was affected by the cyanide fumes and soon became rotten and unfit for use. In our experiments linseed oil painted canvas tents were used for three years and at the end of that time were still in good condition. Due to the irregular and seasonal periods suitable for fumigation, the canvas is not attached to the frame so that is may be removed, folded and stored in a dry place when not in use.

Generating jar. 600 cc heavy Pyrex glass beakers were found very satisfactory for our work. Porcelain covered earthen butter jars of about the same size were also used and were less easily broken. The generating jar was set in a small box just large enough to accommodate it to prevent tipping over. A thin board fifteen inches square was leaned over the jar during fumigation to prevent the spattering of the acid on the bush or canvas.

Chemicals. In our experimental work varying amounts of sodium cyanide were used but it was found that using the above described tent, two ounces was the most satisfactory dosage for producing the most uniform control.* The sodium cyanide may be purchased in "egg" form, each egg weighing one ounce, and this will require no weighing. Two of the eggs may simply be placed in a paper bag. If lump cyanide is purchased it should be carefully weighed out into two-ounce charges and each charge placed in a bag ready for dropping into the generating jar.

Commercial sulphuric acid and water are measured out separately and placed in the generating jar at the time of the fumigation. For two ounces of cyanide use six ounces of water and three ounces of sulphuric acid. It is important to *pour the acid into the water* in order to prevent spattering.

In addition to the above described equipment a spade, a dependable Fahrenheit thermometer, a graduate for measuring the acid and water, scales for weighing the cyanide and small paper bags should be provided.

METHOD OF FUMIGATION

The frame is first placed over the boxwood to be fumigated so that one corner of the space within is more remote from the bush than the others. The gas generating jar is to be placed in this corner. The canvas is next placed over the frame and the top, ends, and sides are pulled flat. The margin or sealing flap is laid flat on the ground and the corners of the tent are compressed and folded across the ends. (See Fig. 2). The margins of the canvas on the ground are then covered with earth spaded up and thrown on them except for a short length near the corner where the generating jar is to be placed. The generating jar containing the acid and water is then installed under this corner of the tent, and the paper bag containing the cyanide is dropped into the jar. The square board is leaned at an angle over the box and jar to shield the canvas from spattering chemicals. The last portion of the tent margin is then quickly laid flat on the ground and some earth thrown upon it to completely seal the tent. Finely divided soil rather than hard lumps should be used so that it may be readily pressed down with the feet to close any fair passage beneath the canvas edges due to irregularities in the ground surface.

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* Lower dosages gave poor kill of larvae and higher dosages, even five ounce dosages at three hours' exposure, did not give a complete kill of all larvae, and did increase the amount of injury at the border lines of safety, mentioned later.

The tent is left closed for one hour to allow the gas sufficient time to act most effectively. At the end of this time the tent is opened. To do this, two men at opposite ends pull out the folded corners of the same side, draw the margin of the canvas on that side clear from beneath the loose soil and throw it on top of the frame. The men must avoid breathing during the opening of the first side and, when opened, immediately step away from the tent for a few minutes to avoid the escaping gas. The opposite side is then opened as was the first, the canvas at the ends is thrown on the frame and the whole is lifted to another boxwood. (See Fig. 2).

The liquid left in the generating jar should be poured into a hole dug in some waste ground and covered. If any is accidently spilled on the hands or clothing it should be quickly washed off. While one man is emptying the generating jar and refilling with acid and water for the next fumigation, another is arranging the canvas and covering the margin with soil. With practice we found that two men were able to open a tent at the termination of a fumigation, place it on another plant, seal it and set off the charge in six minutes. The two men were able to care for six fumigation units by timing them so that when a fumigation was started in one tent, another was ready to be opened.

PRECAUTIONS TO BE OBSERVED IN FUMIGATION

The experimental work was conducted during various seasons of the year and under varying weather conditions to determine the conditions necessary for successful treatment by this method. These conditions are:—

1—Dormancy of plant. The boxwood plant must be in a dormant condition to be safely fumigated. In our experience this condition was attained in the autumn after heavy frosts, usually about the middle of November. The plants may then be fumigated until cold weather sets in, on warm days during the winter, or in the early spring until the sap begins to rise in the plants, which is before the buds swell.

We have experienced no injury in the spring until after the blooming of silver maple *(Acer saccharinum)* and of forsythia, or until the buds of lilac *(Syringa vulgaris)* and of California privet *(Ligustrum ovalifolium)* had swelled and were showing green. Fumigations made later in the spring and before dormancy is attained in the fall will result in the killing of foliage and small twigs or of the entire plant.

Mid-summer pruning induces late growth which does not harden as early in the fall as does the normal growth of May and June. For this reason it is advisable to postpone the fumigation of such plants until spring to insure proper hardening of the wood. Then, if the plants are winter-killed before spring, the injury cannot be blamed to fumigation.

2—Moisture. The plants are injured if fumigated while the foliage is wet with dew, rain, fog or frost. For this reason the work should not be begun until the foliage has dried thoroughly in the morning and should be discontinued before the falling of the dew in the evening. In our experience this generally included the time between 11:00 a. m. and 5:00 p. m. Misty or foggy days should be avoided. The nightly heavy precipitation of dew in the Philadelphia region precluded the possibility of fumigating the plants at night. Examples of injury resulting from fumigations at night were observed.

3—Temperature. Probably the ideal temperature range is between forty degrees and fifty-five degrees Fahrenheit on a sunny or partially cloudy day. The presence of the sun insures the proper drying off of the plants and also raises the temperature in the tent from ten to twenty degrees. The temperature in the tent during fumigation will then range from fifty-five to seventy degrees Fahrenheit. At an outdoor temperature of sixty to sixty-five degrees Fahrenheit, the temperature in the tent will exceed seventy-five degrees and severe injury is very likely to result.

EFFECT OF FUMIGATION

1—Effect on the plant. Immediately upon opening a tent at the close of fumigation the foliage of the plant has a slightly oily appearance. Normally this disappears within a day or two. The starting of growth on the fumigated plants in the spring is generally delayed several days as compared to untreated plants. In a short time, however, there is no difference in appearance.

Fumigations made a little too early in the fall or too near the end of the spring season resulted in a water-soaked appearance of the lower leaf surface which was evident at the termination of fumigation. Within a few hours the lower epidermis swelled out and separated from the remainder of the leaf; the space within filled with a watery liquid. In a few weeks the liquid disappeared and the lower leaf area returned to its normal position but appeared brown instead of green. However, the plant was not reduced in vigor because of this type of localized injury.

Plants fumigated under unfavorable conditions of dormancy, temperature or moisture will show the spotting and bleaching of foliage and death of twigs within a few days. Larvae in all injured leaves die at once, but in successfully fumigated plants behave as described below.

2—Effect on the larvae. When the infested leaf is opened the normal larva waves the tip of its abdomen about or rolls about parallel with its longitudinal axis. The body is turgid and is of an opaque lemon yellow in the anterior region, and more definitely lemon yellow posteriorly.

Immediately after fumigation the larvae are limp and apparently dead, but in a few days they take on the habits and appearance of normal larvae. Larvae in plants fumigated in November may appear entirely normal until March. These larvae do not increase in size to any extent and there is very little enlarging of the mines, which indicates an abstinence from feeding. The body becomes darker in color and develops a transparent median stripe which is more distinct posteriorly. In early April the posterior tip of the abdomen develops a brownish area interiorly and this progresses forward. The insect soon dies and the browning progresses more rapidly so that within a few days it includes the entire body. The body then shrivels to a crooked brown thread.

The larvae fumigated in the spring are first stupefied, then they recover but fail to increase in size, to enlarge their mines, or to cut through the transparent "windows" as the season advances. The transparent stripe develops in April or May and death occurs and final decomposition sets in during May or early June.

The effect of the cyanide fumigation on the larvae is not one of direct asphyxiation as with fumigation of scale, or of greenhouse or other insects; instead it seems to interfere with the processes of food assimilation or of digestion. Larvae which finally die from the effects of fumigation do not increase in size or enlarge their mines to any extent. The development of the transparent condition probably represents a gradual wasting away of the body tissue due to lack of nourishment. The browning of the body posteriorly is evidently a final breaking down of the viscera and accompanies death. Final decomposition of the body is doubtless greatly delayed because of the exclusion of any contaminating bacteria from the closed mines.

The most striking difference between fumigated and normal larvae, discernable before any visible difference is noted, is the lack of the faint rustling sound produced by the latter (6). The sound is produced by the larvae wriggling within their mines and somewhat resembles the bursting of bubbles in thick boiling syrup. On warm sunny days in the spring, one can detect the sound by listening closely with the ear held near the side of the bush. By listening beside an unfumigated plant until the rustling is heard and then comparing the absence or reduction of the sound from a fumigated plant, one can obtain a quite accurate estimate of the success of the treatment. If one depended entirely upon the visible changes in the larvae for a rather long period after fumigation, he would conclude that the treatment had been a failure. This method of listening seems to be an early and a fairly accurate method of estimating the control.

SUMMARY OF CYANIDE FUMIGATION

Use two ounces sodium-cyanide to one hundred cubic feet.

Generate the gas with three ounces sulfuric acid and six ounces water.

Use a linseed oil-treated, twelve ounce canvas for the tent.

Seal the edge of the canvas with soil.

Open the tent after one hour's exposure to the gas.

Conditions necessary for successful treatment.

a. Complete dormancy of plants. (Middle of November to March.)

b. Plants must be dry.

c. A temperature range of from 40° to 55° F. (Higher temperatures will produce damage to plants.)

HOT WATER IMMERSION

The nurseryman who is transplanting his stock or is digging plants for sale will find that the treatment with hot water is practicable commercially and that it will kill one-hundred per cent of the larvae. This method, developed by the Pennsylvania Bureau of Plant Industry (7), was further tested on a commercial scale by Cory and Graham (2). They found that the cost of treatment per plant was about 7.8 cents.

The equipment for this work consists of one or more tanks for immersing the plants in the water, and a steam supply either from a greenhouse boiler or from a special boiler. The tanks should be slightly greater in depth than the height of the plants to be dipped. In our experimental work a galvanized tank twenty-four inches in diameter and thirty inches deep was used. (See Fig. 3.) Four plants, each eighteen inches high, could be treated at one time in it. Cory and Graham (2) used five barrels for treating tanks in one case, and in another, a tank three feet deep, four feet wide and six feet long. (See Fig. 4). Hose or pipe connections for water and steam are run into the tank. Hand valves in the connections are provided near the tank so the operator can adjust the steam flow and so regulate the temperature of the water. An accurately calibrated Fahrenheit thermometer is suspended in the tank.

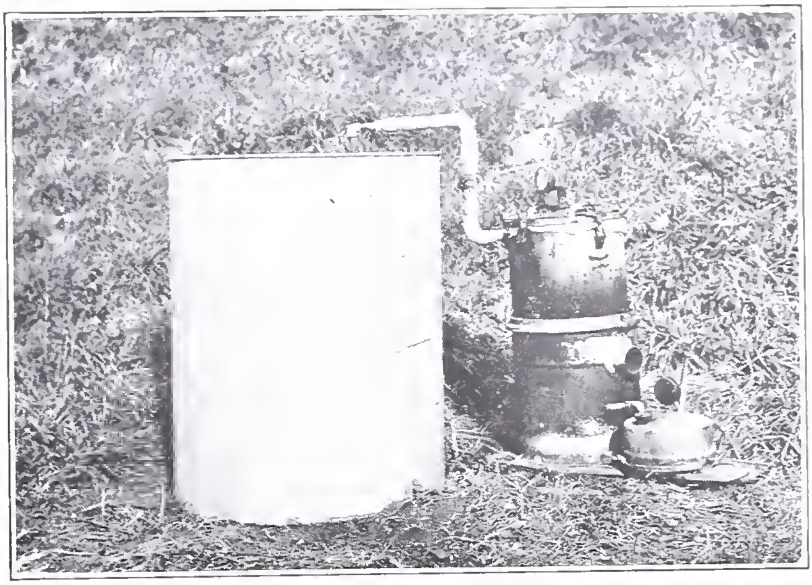
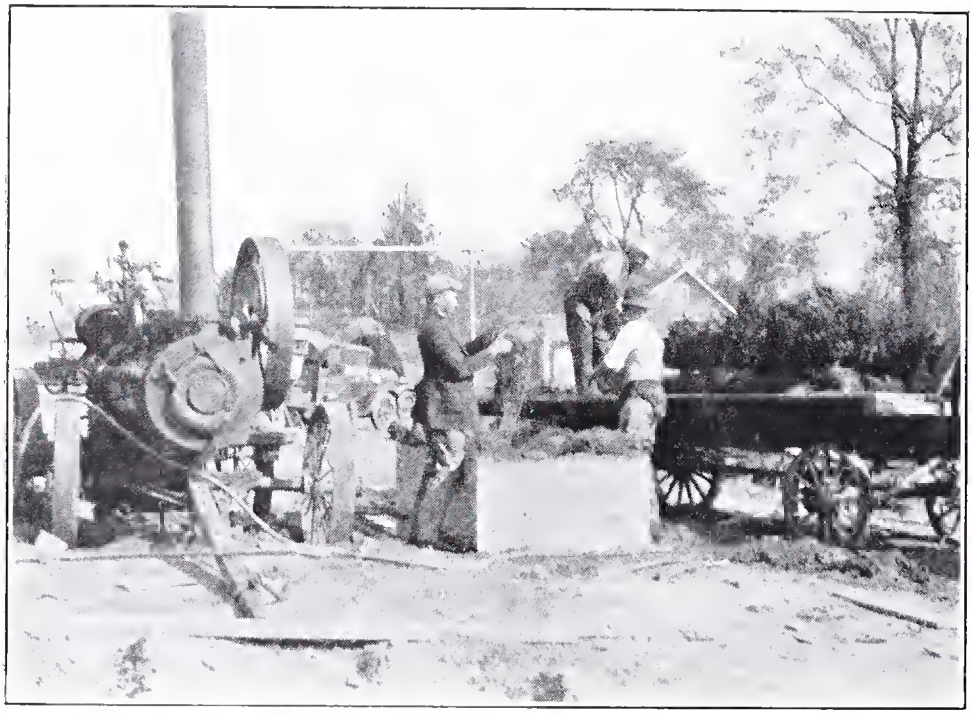


Fig. 3. Small Tank Used In Experimental Hot Water Treatments

The method of treating is as follows: The water in the tank is maintained at a level of one or two inches from the top and is kept heated to the required temperature of 120 degrees Fahrenheit. It is frequently stirred with a paddle to maintain an even temperature in all parts of the tank. The temperature should be frequently read and as it falls or rises the rate of steam flow should be accordingly increased or decreased. The boxwood plants, after being dug, should have the soil ball wrapped with burlap to prevent breaking of the ball and dropping of soil into the tank. Extreme care should be taken in wrapping to prevent the inclusion of any lower branches which would then be protected from the hot water and thus permit larvae to escape the treatment. The plants are inverted in the tank and lowered into the water to the soil surface. Too many plants should not be immersed at one time as this crowds the tops and prevents the free circulation of the water. Small plants are handled by hand. Larger plants are raised above the tank and then lowered into the water by means of a rope and pulleys which are suspended from a scaffold and hooked into a loop of rope about the soil ball. During treatment the soil balls are allowed to rest on the edge of the tank or between pieces of 2″ x 4″ laid across the tank. After the plants have been immersed for the required time, they are removed from the water and are then ready for replanting in an area some distance from any source of infestation.



—Photo by E. N. Cory, University of Maryland.

Fig. 4. Hot Water Tank in Use in Maryland

Our experiments showed that the leaf miner larvae varied considerably in their resistance to heat according to the season and to their stage of growth. At 120 degrees Fahrenheit water temperature, an immersion of ten minutes was required in July and August, seven minutes during the last half of September, and five minutes during October and the spring treating period, (March to mid-May.) Although the late summer and fall treated plants survived the following winter in good condition in most cases, some losses were incurred both among the treated plants and the untreated check plants which were handled in the same way except for dipping in hot water. The spring treated plants grew very well following treatment and transplanting. The plants treated in the early spring before the buds swelled produced normal growth with no indication of injury. The newly developed growth present on plants treated later in the spring was killed by the hot water, but new adventitious growth was soon produced and all indications of injury were hidden by mid-summer.

Our recommendations for the best time to treat the plants would be in the early spring before growth starts. Later spring treatment, with its resulting temporary injury, is to be preferred to fall treatment. Fall treatment is not preferred because of the hazard incurred in transplanting at that season of the year.

DISCUSSION

The two new methods of attacking the boxwood leaf miner, fumigation and hot water treatment, have certain limitations and uses.

The control by fumigation with sodium cyanide cannot be depended upon to give a complete kill of all larvae in a plant but only a uniformly high percentage of them. Therefore, it cannot be recommended as a treatment for certification of plants for shipment. However, fumigation of established plants on estates and public grounds will be found to be a practical method for greatly reducing the infestations. If the fumigation is followed during the spring emergence period with a careful spray program to destroy the few surviving individuals, a complete eradication would be almost assured. The dangerous nature of the chemicals, the necessity for the presence of certain temperature, moisture and weather conditions, and for the dormant state of the plant, limits the conduct of fumigation only to responsible persons.

The hot water treatment, properly conducted, will kill all larvae present in infested plants. Its use will probably become a nursery practice as a prerequisite to certification for shipment of infested plants. Where plants are being dug for transplanting to an isolated location, its use is an economical method of freeing the plants of the leaf miner. The treatment is simple, is not dangerous to the operator, and requires few precautions or directions for successful use.

Both treatments control the boxwood psyllid *(Psyllia buxi Linn.)*.

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